

## Blue Laser for Ice and Melt Pond Lidar Applications

Completed Technology Project (2014 - 2015)



## Project Introduction

Lidar has been utilized for decades to study the cryosphere and its study is a core science product of several national organizations, including NASA, NOAA, and many commercial and academic institutions. The state-of-the-art airborne lidar systems performing this research often operate at a wavelength of 532nm, but research has shown that 420-460 nm light can penetrate relatively clear water and ice much deeper before experiencing significant absorption loss. We propose to design and build a new blue laser system to make measurements on ice and melt ponds not previously possible, and we will confirm how well the light penetrates these targets using the GSFC Code 615 Snow and Ice Research Facility.

This project proposes to achieve the following objectives:

1. Design and assemble a 420-460 nm laser system that is deployable for science and commercial applications.
2. Test the penetration properties of the 420 -460 nm laser light in the Code 615 Snow and Ice Research Facility to quantify how much better it performs compared to 532 nm.

If these goals are successfully achieved, the blue laser will be in excellent position to integrate with in-house airborne systems within one year. Once airborne demonstrations are successful, the blue laser can support any IceBridge operation and also be scaled to support any space-based ice lidar missions.

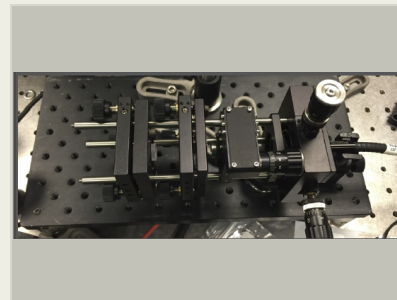
The work plan to develop the proof-of-concept pulsed blue laser transmitter and test 440 nm penetration properties is detailed below. All facilities and equipment required to carry out this plan already exist here at GSFC in Code 554 and Code 615.

*October -January 2014:* Finalize design of laser with a focus on reliability, ease of pumping, and nonlinear conversion efficiency, while eyeing future systems-level configuration considerations. Use software to select nonlinear crystal(s) and optimize dimensions. Ordering and procurement of pump diodes, gain media, optical components, nonlinear conversion crystals, and various electronics. Start basic design of final mechanical packaging.

*January-February 2015:* Assemble and characterize performance of laser at fundamental wavelength. Test peak power, pulse width, output spectrum, and energy up to 10 kHz repetition rate.

*March-May 2015:* Characterize performance of nonlinear frequency conversions stage(s) to achieve target blue wavelengths. Optimize conversion vs. temperature & alignment. Characterize overall performance of laser transmitter. Start repackaging of breadboard setup to aircraft-compatible packaging.

*June-August 2015:* Complete aircraft-compatible packaging of the blue



Lidar Applications Project

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## Organizational Responsibility

**Responsible Mission Directorate:**

Mission Support Directorate (MSD)

**Lead Center / Facility:**

Goddard Space Flight Center (GSFC)

**Responsible Program:**

Center Independent Research & Development: GSFC IRAD

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wavelength laser and move it to the Snow and Ice Research Facility. Use facility resources to test the transmit absorption/reflectance characteristics of laser, mirroring ICESat-2 experiments. A direct comparison can then be made between 532 nm and 450 nm light such that we can understand which ice applications ~ 450 nm wavelength would offer superior performance.

## Anticipated Benefits

Current bathymetric and ice lidars generally use green light (*e.g.*, NASA Langley's HSRL-1 lidar) are limited by the penetration depth of 532 nm light, and their application is generally limited to certain specific targets. At 440 nm, the absorption coefficient for water is approximately an order of magnitude smaller than at 532 nm, offering substantial improvement in ranging through water for the same optical power output, thus reducing power requirements. Therefore, a 440 nm lidar presents an opportunity to improve systems performance and the science product over existing targets.

Melt ponds on arctic sea ice are a particularly interesting objective, as they are of primary importance to the disintegration of sea ice during the spring and summer. Because of their lower albedo compared to the surrounding snow-covered sea ice, melt ponds are areas of intense absorption of solar radiation and heat which promotes growth of the melt pond at the expense of the sea ice. A blue wavelength lidar would allow for improved melt pond (lighter colored region in the left of Figure 2) depth retrieval, as well as characterization of the ocean water (dark region in the right of Figure 2) between ice flows. This information would be extremely valuable in understanding the seasonal cycle of sea ice decay.

Similarly, melt ponds on land ice also grow through this albedo feedback effect and often drain through the ice sheet, increasing the sliding speed of ice sheet toward the ocean. A 420 - 460 nm lidar system would allow for high-precision measurements of melt pond geometry, and this information could be used to better characterize their formation, growth and decay. This information would be key for both understanding the hydrology of the ice sheet surface and the impact of lake draining on the basal sliding speed. Given the improved penetration of ~ 450 nm laser light compared with 532nm light, such a system could survey deeper lakes (10s of meters) with far less power than would be required from a 532 nm - based system. Therefore the system could provide a better data product more efficiently (both technically and economically) than current 532 nm lidars.

The timing of this work is particularly apt, as NASA's ongoing Operation IceBridge provides a natural fit for a low-power blue lidar. We anticipate field testing this system through a 2015 ROSES solicitation for Cryospheric Sciences (call A.15), followed by a response to the next competition for IceBridge instrumentation in 2016.

Currently, there are some underwater mapping and laser communication

## Project Management

### Program Manager:

Peter M Hughes

### Project Manager:

Terence A Doiron

### Principal Investigator:

Paul R Stysley

### Co-Investigators:

Barry Coyle

Demetrios P Poullos

Thomas A Neumann

## Technology Areas

### Primary:

- TX14 Thermal Management Systems
  - └ TX14.2 Thermal Control Components and Systems
    - └ TX14.2.6 Heating Systems

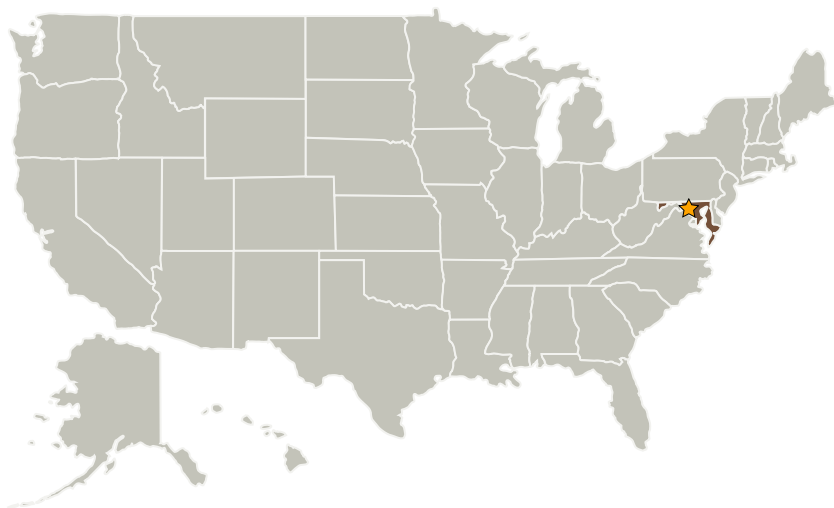
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applications that this laser system could provided support for run by NOAA and the US Navy.

## Primary U.S. Work Locations and Key Partners

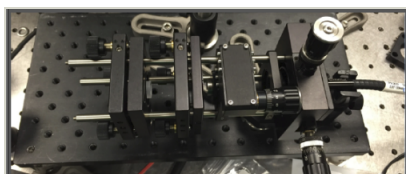


Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

## Primary U.S. Work Locations

Maryland

## Images



## Lidar Applications Project

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(<https://techport.nasa.gov/image/17632>)

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### Links

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(no url provided)

### Project Website:

<http://sciences.gsfc.nasa.gov/sed/>